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ABSTRACT

This packet is one in the "Exploration" series of curriculum materials developed for junior high and middle school industrial educators. The Exploration Series is intended to help them provide seventh- and eighth-grade students an opportunity to explore a wide range of industrial situations as well as some of the technologies used in the industry. The documents may also serve as a resource for teachers orienting ninth- and tenth-grade students to the industrial technologies of communication, production, energy utilization, and transportation and the impact of industry and technology. This packet is one unit in the energy utilization technology area. It includes a rationale, hints to the teacher, lesson plans for three lessons (objectives, lesson content, and learning activities), student handouts for each lesson, teacher aids for the lessons, a unit examination, and a list of references. The lesson topics are passive solar energy, active solar energy, and evaluation. (YLB)

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The Illinois Plan for Industrial Education

Illinois State Board of Education

Adult, Vocational and Technical Education

ED296095

EXPLORING SOLAR ENERGY

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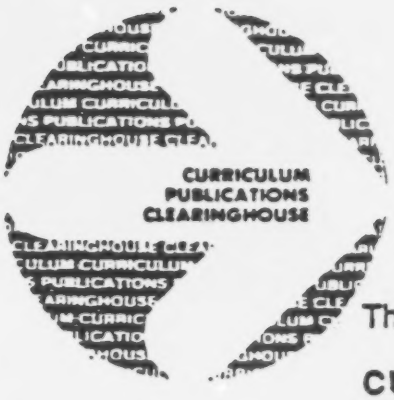
PACKET INCLUDES:

- Rationale
- Hints to the Teacher
- Lesson Plans
- Student Handout Masters
- Teacher Aides
- Unit Examination
- References



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INTRODUCTION

The development of this publication was made possible through grants from the Illinois State Board of Education, Department of Adult, Vocational and Technical Education, Research and Development Section, 100 North First Street, Springfield, Illinois 62777. Opinions expressed in this document do not reflect, nor should they be construed as policy of the State Board of Education or its staff.

"Exploring Solar Energy" is one of a series of curriculum materials developed for junior high and middle school industrial educators. Listed below are the titles of the units in the series.

Communication
- Using the Language of Industry
- Exploring Computer Technology
- Exploring Photography
- Exploring Graphic Communication
- Exploring Electronic Communication

Energy Utilization
- Exploring Solar Energy
- Using Alternate Energy Sources
- Conserving Energy Sources
- Exploring Electricity/Electronics
- Exploring Mechanical and Fluid Systems

Impact of Industry and Technology
- Recycling Materials
- Limiting Pollution
- Exploring Careers in Industry and Technology
- Exploring Technology and the Future

Production
- Exploring Materials and Processes
- Exploring Construction Technology
- Research and Development
- Exploring Manufactured Systems
- Servicing Products

Transportation
- Exploring Land Transportation Systems
- Exploring Aviation Technology
- Exploring Water Transportation Systems
- Exploring Space Transportation Systems
- Exploring Materials Handling Systems

The Exploration Series was developed to help industrial educators provide 7th and 8th grade students an opportunity to explore a wide range of industrial situations as well as some of the technologies used in industry. In addition, these documents can serve as a resource for teachers orienting 9th and 10th grade students to the industrial technologies of communication, production, energy utilization and transportation. Each unit in the series includes a rationale, hints to the teacher, lesson plans, student handouts, teacher aids, a unit examination, and a list of references.

"Exploring Solar Energy" and other units in the series are available on a cost recovery basis through the Curriculum Publications Clearinghouse, Western Illinois University, Horrabin Hall 46, Macomb, IL 61455.

EXPLORING SOLAR ENERGY
RATIONALE

During these times of skyrocketing energy costs, it is vital for everyone to become aware of new technologies and their applications. Although solar energy has been recognized and used for centuries, it has only been in the later part of this century that it has grown into a technology of its own. The increase in prices of fossil fuels and the growing concern for energy sources has emphasized the viability of solar energy as a renewable resource.

At a distance of 93 million miles from the sun, the earth intercepts approximately 2 billionths of the sun's radiant output or the equivalent of about 35,000 times the total energy used by all people in one year. From this fact, one can see that the energy potential is there and strides are being made in harnessing that energy for human use.

Each year the world consumes as much oil as it took nature 2 million years to create. Presently, the world is dependent on finite fuels. However, energy trends indicate that world oil production will peak and start a long downward slide around the 1990's, if not sooner. Developing replacements with alternative energy sources will be difficult, time consuming and expensive.

It is necessary to educate this next generation now so that they can become more aware of the problems as well as the possibilities of new technologies. It will be their responsibility to deal with the emerging dilemmas of energy supplies and demands. Solar energy is a viable alternative and an important factor in assessing future energy resources.

HINTS TO THE TEACHER

1. Consider using the unit titled "Using Alternate Energy Sources" to compliment this unit.

2. Most of the lessons require the teacher to make some of the components necessary to conduct the laboratory activities. You will need to read each lesson carefully, acquire the materials, and make the required devices prior to teaching each lesson.

3. These materials include several handouts for the students to read. You may want to read the handouts and write study questions for them. The questions should identify main ideas you feel are important.

4. Prior to implementing this lesson, consider contacting your local utility company. Many utility companies in Illinois have public relations programs that will provide your school with pamphlets on various alternate energy sources, including solar energy.

5. In the reference section, a list of possible sources for brochures and education aids has been provided. Take advantage of these free materials as they often contain useful information and creative learning activity ideas.

6. Consider conducting a field trip to a solar home or building near your school. People who own solar homes are often willing to conduct tours and explain their solar energy system.

7. Consider inviting a representative from an architectural firm or solar energy company to talk to your class about solar energy technology.

8. To ensure student success, implement this unit early in the fall or late in the spring. Given solar energy, the recommended solar energy devices will work almost anytime of the year. However, temperature gain will be more impressive if the devices are tested during mild weather.

9. This unit provides several opportunities to promote technology education in your school community. Consider taking pictures of your students making and testing passive and active solar devices. Consider inviting school administrators and the press to observe your students' solar energy experiments.

UNIT: Exploring Solar Energy

LESSON 1: Passive Solar Energy

Objectives	Lesson Content	Learning Activities	Ref.
A. Following a discussion, students will be able to: -identify the two basic characteristics of passive solar technology. -identify a definition for direct gain systems. -identify a definition for indirect gain systems. -identify four basic applications for passive solar technology. -identify four basic passive solar energy conversion processes. -identify the two types of thermal mass commonly used in passive solar energy systems.	A. Passive solar energy 1. Characteristics of passive solar technology a. takes advantage of the sun's radiant energy for heating and cooling without dependance on energy consuming devices like fans and pumps. b. utilizes architectural design, orientation, and composition to collect, convert, store, control, and distribute energy.	A. Teacher Guided Discussion 1. Ask students why parked cars get so hot in the summer. Ask students to identify the source of the heat. 2. Using OT #1-1, discuss the definition for passive solar energy. 3. Using OT #1-2, introduce students to the two basic types of passive solar systems. 4. Using OT #1-3, discuss a definition for direct gain systems.	

2. Passive solar techniques
   a. direct gain systems
   b. indirect gain systems
3. Direct gain systems
   a. solar energy directly enters the living space through south facing glass.
   b. thermal mass is located within the living space.
   c. collection, conversion, storage and distribution of solar energy occurs within the living space.
4. Indirect gain systems
   a. solar energy must pass through south facing glass and a thermal mass before entering the living space.
   b. thermal mass is located between south facing glass and the living space.
   c. collection, conversion, storage, and distribution of solar energy occurs between south facing glass and the thermal mass.
5. Using OT #1-4, discuss a definition for indirect gain systems.
6. Using OT #1-5, discuss the four basic elements in the passive solar energy conversion process.
7. Using OT #1-6, introduce students to the two basic types of thermal mass.
8. Using OT #1-7, discuss the basic applications for passive solar technology.

5. Solar energy conversion processes.
   a. collection
   b. conversion
   c. storage
   d. distribution
6. Basic types of thermal mass
   a. water
   b. masonry
7. Solar energy applications
   a. lighting
   b. heating living space
   c. heating domestic hot water
   d. growing plants
   e. drying grain
   f. drying lumber

B. Following a demonstration, in a lab activity, students will be able to: -construct a working passive solar mockup. -conduct experiments regarding collection, conversion, storage, and distribution variables according to written and verbal instructions. -collect, graph, and interpret data regarding their passive solar mockup's performance.	B. Making and testing passive solar mockups. 1. Making a passive solar mockup a. making an enclosure b. glazing the enclosure c. installing a thermometer inside the enclosure 2. Testing the passive solar mockup a. testing absorber surface colors b. testing the effects of insulation c. testing thermal mass materials d. testing a convection loop distribution system 3. Conclusions a. collecting data b. graphing data c. interpreting data d. answering questions	B. Learning Activities 1. Demonstrate how to use the tools and materials needed to make passive solar mockups. 2. Demonstrate how to make a passive solar mockup. 3. Provide each student with HO #1-1 and review the lab sheet provided. 4. Divide your class into teams and assign each team a work station. 5. Have students begin making their passive solar mockups. 6. Circulate around the room and provide individual instruction as needed. 7. When students have finished their mockups, escort them to an outdoor site with an unobstructed orientation to the sun. 8. Have students orient their mockups toward the sun for maximum solar gain and have them conduct the experiments on the lab sheet.

9. Circulate around the site and provide individual instruction as needed.
10. When students have completed the lab activities, collect and evaluate their lab sheets. Review the concepts experienced and discuss the results of the lab activities.

PASSIVE SOLAR ENERGY

Preparation Hints:

1. Review the materials provided, duplicate HO #1-1 through HO #1-5, and prepare the transparencies needed to present this lesson.

2. During the lab activity, your students will be making passive solar mockups. Prior to implementing this lesson, you will need to collect and organize the materials listed in the handout. The corrugated cardboard could be obtained from a local department or food stores. Duct tape and polyethelene plastic can be purchased from most hardware stores.

3. During the lab activity, your students will be testing a variety of absorber surface colors. Prior to implementing the lesson, you will need to prepare several hardboard panels that can be inserted into passive solar mockups. Paint an even number of panels silver or white, and flat black. During the lab activity, students will test the effects of both colors in a passive solar system.

4. During the lab activity, students will be testing the effects of insulation on their passive solar mockups. Prior to implementing this lesson, obtain sheets of styrofoam, fiber glass, or polyisocyanurate insulation.

5. During the lab activity, students will be testing a variety of thermal mass materials. Prior to implementing this lesson, you will need to collect aluminum pop cans. Each can will need to be painted flat black and filled with a thermal mass material. Possibilities for thermal mass materials include water, sand, pebbles, and small metal fasteners.

6. During the lab activity, your students will need to collect data regarding the temperature of their passive solar mockups. Each team will need a thermometer. Consider borrowing thermometers from your school's science department. If you cannot borrow thermometers, consider using outdoor or automobile thermometers.

7. If you have access to a microcomputer, consider using a data acquisition program so your students can collect temperature data electronically. The two data acquisition programs commonly used in schools are:

    * Science Tool Kit, published by Broderbund Software, Inc.

    * Temperature Grapher, published by Human Relations Media

8. Consider making and testing a passive solar mockup prior to implementing this lesson. Experimenting with your own passive solar mockup will enable you to test your materials, identify problems, and develop strategies to insure student success. In addition, students will be able to refer to your example when making their own passive solar mockup.

Content Presentation Hints:

1. Consider showing a film or videotape on passive solar energy.

2. Consider conducting a field trip to view and/or tour a solar home or building near your school.

3. Consider asking an architect or contractor to visit your class and talk to your students about passive solar technology.

4. Consider taking your class to the library for one class period. While there, your students could collect a variety of design ideas for their passive solar mockups. In addition, students could also gather information about passive solar collection, conversion, storage, and distribution techniques.

5. Consider establishing a passive solar technology bulletin board. To decorate the bulletin board, students could write to companies that sell plans and/or kits for passive solar homes. In addition, students could cut out and post pictures of passive solar homes and buildings from old magazines.

Learning Activity Hints:

1. During the lab activities, students will be making a passive solar mockup and conducting five experiments. Plan on dedicating at least six lab periods for these activities. On the first day, students could build their passive solar mockup. On subsequent days, students could conduct their experiments, one per lab period.

2. In the event of bad weather, simply postpone the lab activities. Consider building the active solar collectors suggested in the next lesson.

3. To save time, consider making hardboard templates for each part of the passive solar mockup. Students could trace around the templates when cutting out pieces for their mockups.

4. Consider making a second set of templates for cutting out insulation panels. These templates will need to be slightly larger to account for the thickness of the insulation material.

5. Consider dedicating space on your chalkboard for your class chart. The chart could record peak temperatures obtained by each team during each experiment.

6. If you discover there is not enough time for the mock-ups to warm up during each class period, consider locating each them in direct sun light one period before conducting experiments.

7. If your class meets early in the day before solar collection can begin, consider making several alternate light sources (see Figure 1-1). Each light fixture will require a 150 watt heat lamp.

OH #1-1

PASSIVE SOLAR:

-takes advantage of the sun's radiant energy for heating and cooling without dependance on energy consuming devices.
-utilizes architectural design, orientation, and composition to collect, convert, store, control, and distribute energy.

OH #1-3

DIRECT GAIN SYSTEMS:

-solar energy directly enters the living space through south facing glass.
-thermal mass is located within the living space.
-collection, conversion, storage, and distribution of solar energy occurs within the living space.

OH #1-4

INDIRECT GAIN SYSTEMS:

-solar energy must pass through south facing glass and a thermal mass before entering the living space.
-thermal mass is located between south facing glass and the living space.
-collection, conversion, storage, and distribution of solar energy occurs between south facing glass and the thermal mass.

OH #1-5

SOLAR ENERGY CONVERSION PROCESS:

- collection
- conversion
- storage
- distribution

OH #1-6

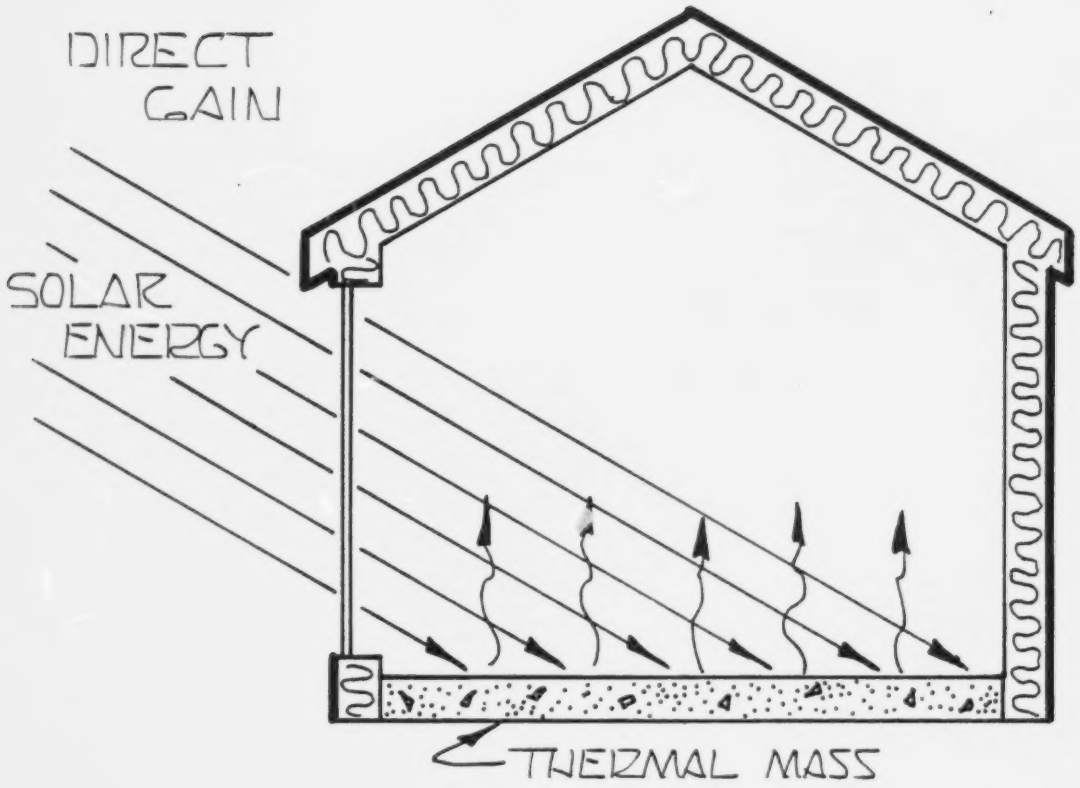
BASIC TYPES OF THERMAL MASS

- water
- masonry

OH #1-7

PASSIVE SOLAR APPLICATIONS:

- lighting
- heating living space
- cooling living space
- heating domestic hot water
- growing plants
- drying grain
- drying lumber


DIRECT
GAIN
SOLAR
ENERGY
THERMAL MASS

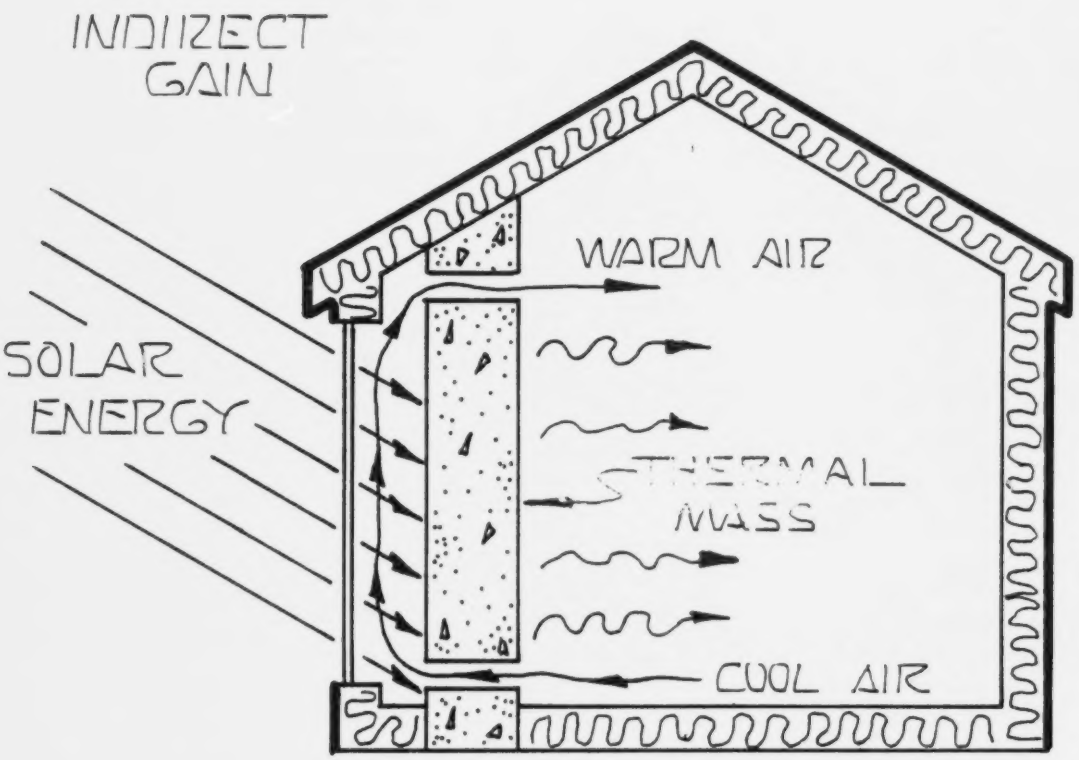
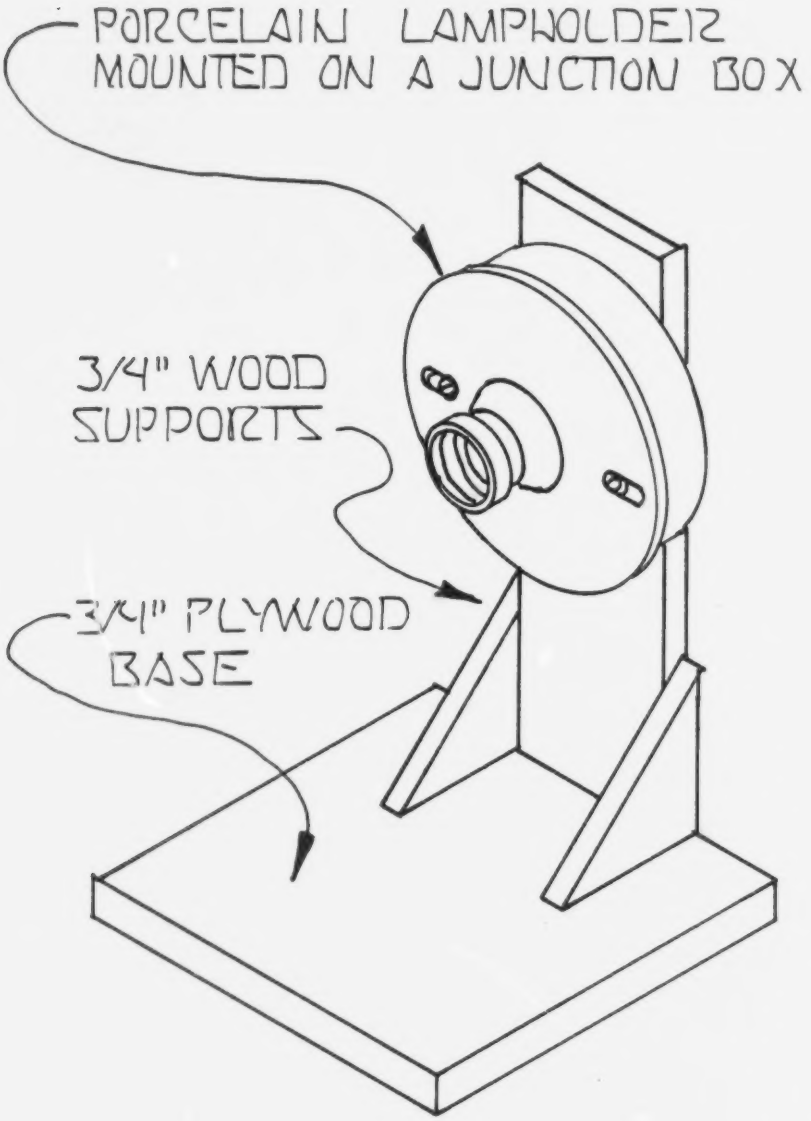

INDIRECT
GAIN
WARM AIR
SOLAR
ENERGY
THERMAL
MASS
COOL AIR

FIGURE 1-1 : ALTERNATE LIGHT SOURCE



PASSIVE SOLAR ENERGY

Discussion:

Solar energy is the energy received by the earth from the sun. It is sometimes referred to as radiant (light) energy. The sun radiates energy in all directions but only about two-billionths of this reaches the earth. This small amount is equal to about as much heat and light as is available from all our known coal, gas, and oil reserves.

Solar energy is free, non-polluting, and safe. Unlike natural gas, coal, and petroleum, we cannot run out of solar energy. It is an inexhaustible energy source. It can do more than warm the earth in the summer and provide light during the day. Solar energy can be used to heat homes and commercial buildings. It can be used to generate electricity. It can even be used to power electronic devices on communication satellites.

Today, studies and tests are being done all over the world to find good ways to use solar energy. Reports have proven that the sun may become a prime source of energy in the future. Did you know that if we could convert the sun's energy at 20% efficiency, the amount of solar energy that reaches an area the size of the state of New Jersey could fill our current needs for electrical power! That fact alone makes the sun's energy an important source.

Solar energy is too valuable to overlook. At a time when fuel costs are growing and supplies are running low, a free source of energy is more attractive than ever. You do not have to pay a utility company for energy when you heat your home with solar energy. Unfortunately, the technology required to put the sun's radiant energy to useful work is very expensive. Solar homes and buildings have to be specially designed to catch the sun's energy and keep it for a long time. Their designs often require extra, and sometimes special, materials that increase the cost of solar buildings.

Passive solar energy technology takes advantage of the sun's radiant (light) energy for heating and cooling without dependance on energy consuming devices like fans and pumps. Passive solar building are especially designed to collect, convert, store, and distribute energy from the sun.

Passive solar buildings use south facing glass to collect solar energy. During the collection process, solar energy is in the form of light. It needs to be converted to

heat. To encourage the conversion process, passive solar buildings include a lot of dark colored surfaces. These surfaces absorb the light and convert it to heat. To prevent over heating, these surfaces are often made of materials that absorb heat. These materials are often referred to as thermal mass. The two most common materials used for thermal mass are masonry (i.e., concrete, bricks, stone) and water. If the temperature inside the building drops, these materials will give up their stored heat to the building. Vents and large open spaces are used to distribute heat throughout the building. Movable insulation and shading (roof overhangs and/or trees) are often used to control the collection process.

Passive solar buildings typically use one of the following techniques:

* direct gain systems
* indirect gain systems

Direct gain systems allow sunlight to enter direction into the living space through south facing glass. The collection, conversion, storage, and distribution processes occur within the living space.

Indirect gain systems have a thermal mass between the south facing glass and the living space. Sunlight passes through the glass, is converted into heat, and is absorbed by the thermal mass. For heat to enter the living space, it must pass through vents at the top and bottom of the thermal mass. In addition, heat can also enter the living space by passing through the thermal mass.

Passive solar energy systems are often used to heat living space and domestic hot water. In addition to providing heat, south facing glass can provide a natural form of lighting.

Passive solar technology can also be used for agricultural applications. Plants can be grown all year round in passive solar greenhouses. Passive solar systems can be used to dry grain and lumber.

Solar energy is one of the most promising energy resources available to humankind. Passive solar buildings use the sun's radiant energy for lighting, heating, and cooling. They use their design, orientation, and composition to collect, convert, store, and distribute energy from the sun. Passive solar systems do not use mechanical devices like pumps or fans. There are two basic types of passive solar systems, direct and indirect gain.

Passive solar technology can also be used to heat domestic hot water, grow plants, and dry grain and lumber.

Learning Activities:

When people think about solar energy, one of the first thing that comes to mind is a house with lots of windows on the south side. The windows collect the sun's radiation and convert it to heat. During the learning activity, you will be building and testing an enclosure with glass on one side. The testing will help you discover how different things affect the temperature in a passive solar enclosure. You will probably be surprised how easy it is to harness the sun's energy.

Making a Passive Solar Mockup:

1. Using the templates provided by your teacher, lay out the parts of your passive solar mockup on corrugated cardboard. Write your name on each part after you have traced its outline with a template.

2. Using a utility knife, cut out each piece of your passive solar mockup. Be very careful when using the utility knife. Make sure you protect the working surface under the cardboard with a piece of hardboard.

3. Once all your parts are cut out, assemble the pieces using duct tape (see Figure 1-2). When assembling your mockup, make sure the back panel opens and closes like the one illustrated in Figure 1-3. This means you will only need to attach its top edge to the mockup. Use several small pieces of duct tape to hold the panel closed at the bottom. When the panel needs to be opened, simply cut the two small pieces of duct tape with a razor knife, make the needed modifications, and retape the bottom two corners.

4. When all the panels of your mockup have been assembled and secured with tape, stretch a sheet of polyethelene plastic across the top face of your mockup. Cut the plastic to size, and secure all its edges with duct tape.

5. Once the polyethelene plastic has been installed, your mockup is ready to be tested. Proceed to HO #1-2.

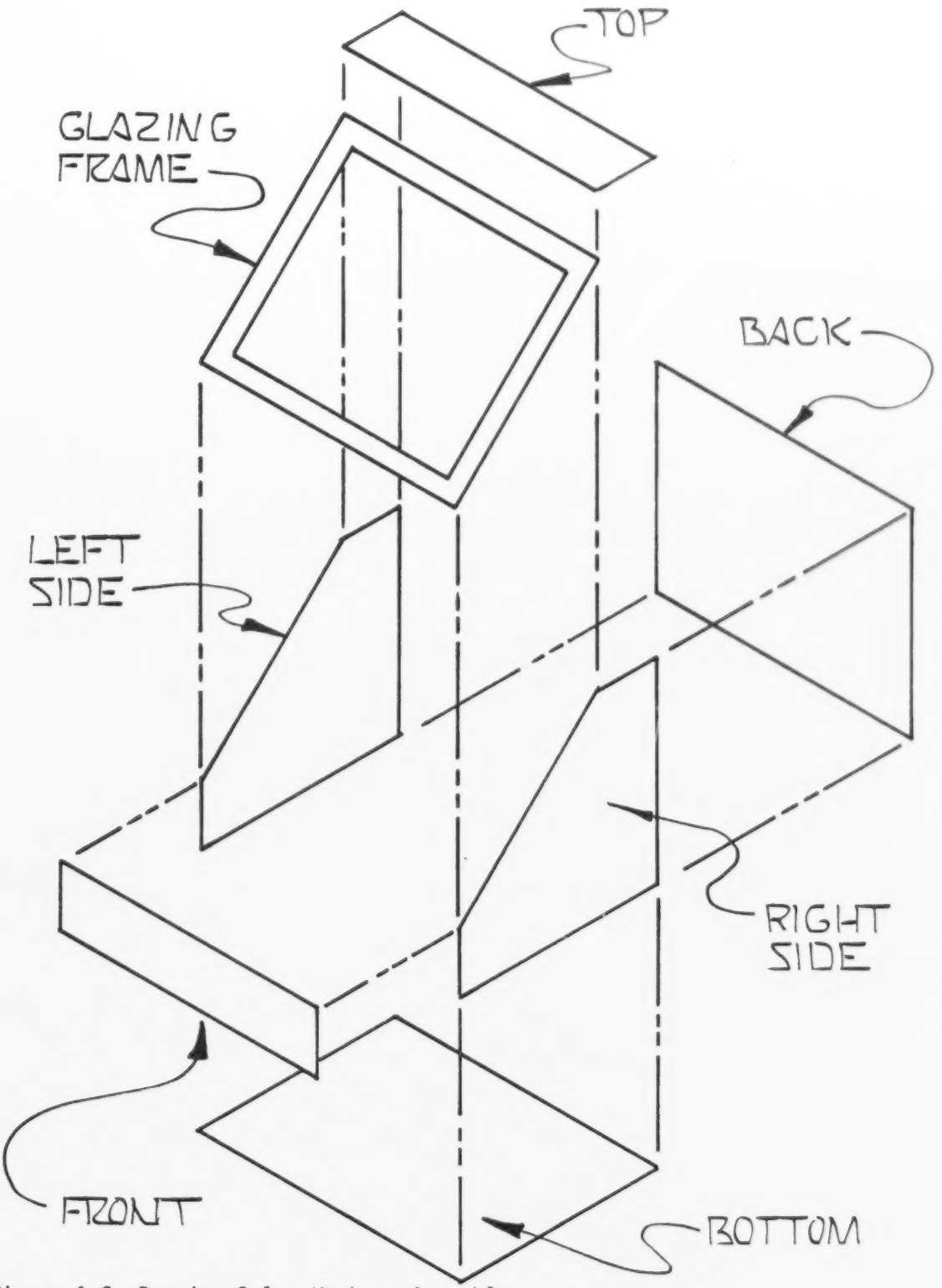


Figure 1-2 Passive Solar Mock-up Assembly

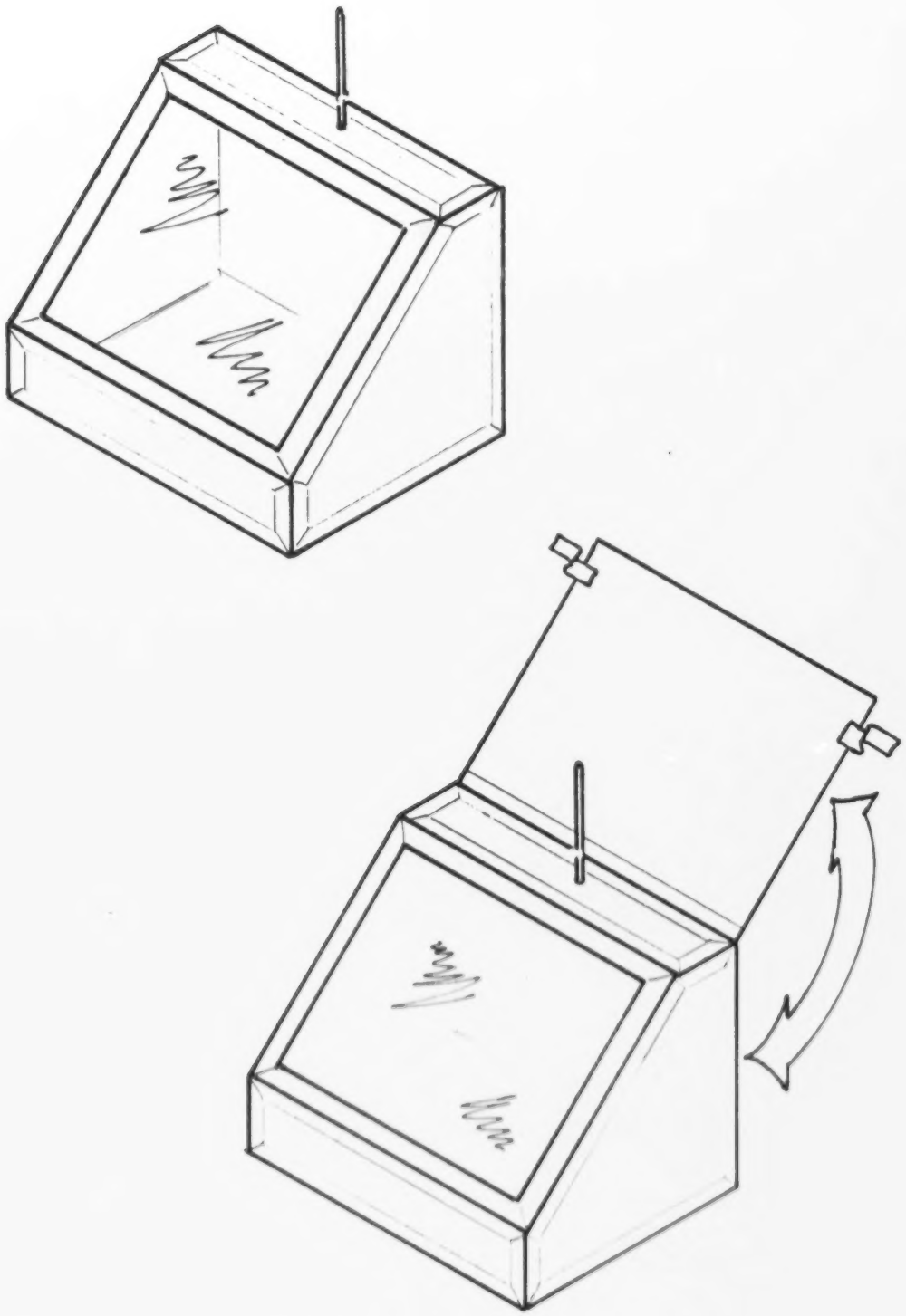


Figure 1-3 Completed Passive Solar Mock-up

TESTING ABSORBER SURFACE COLORS

1. To test absorber surface colors, you will need the following materials:

    * one passive solar mockup
    * one thermometer
    * one set of hardboard panels painted flat black
    * one set of hardboard panels painted white or silver
    * several pieces of duct tape

2. Open the back panel of your passive solar mockup. Install one of the light colored panels across the bottom of your passive solar mockup (see Figure 1-4). Install the other light colored panel across the back of your passive solar mockup. Close the back panel and tape the two bottom corners.

3. Take the mockup to an outdoor site with an unobstructed orientation to the sun. Orient your passive solar mockup toward the sun for maximum heat gain.

4. Install a thermometer through the top of your mockup. Make sure you can still read it easily. Be careful, thermometers break easily.

5. When your teacher tells you it is time to start, read the thermometer and record the temperature readings on the chart provided. Continue reading and recording your mockup's temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: WHITE OR SILVER ABSORBER PANELS

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

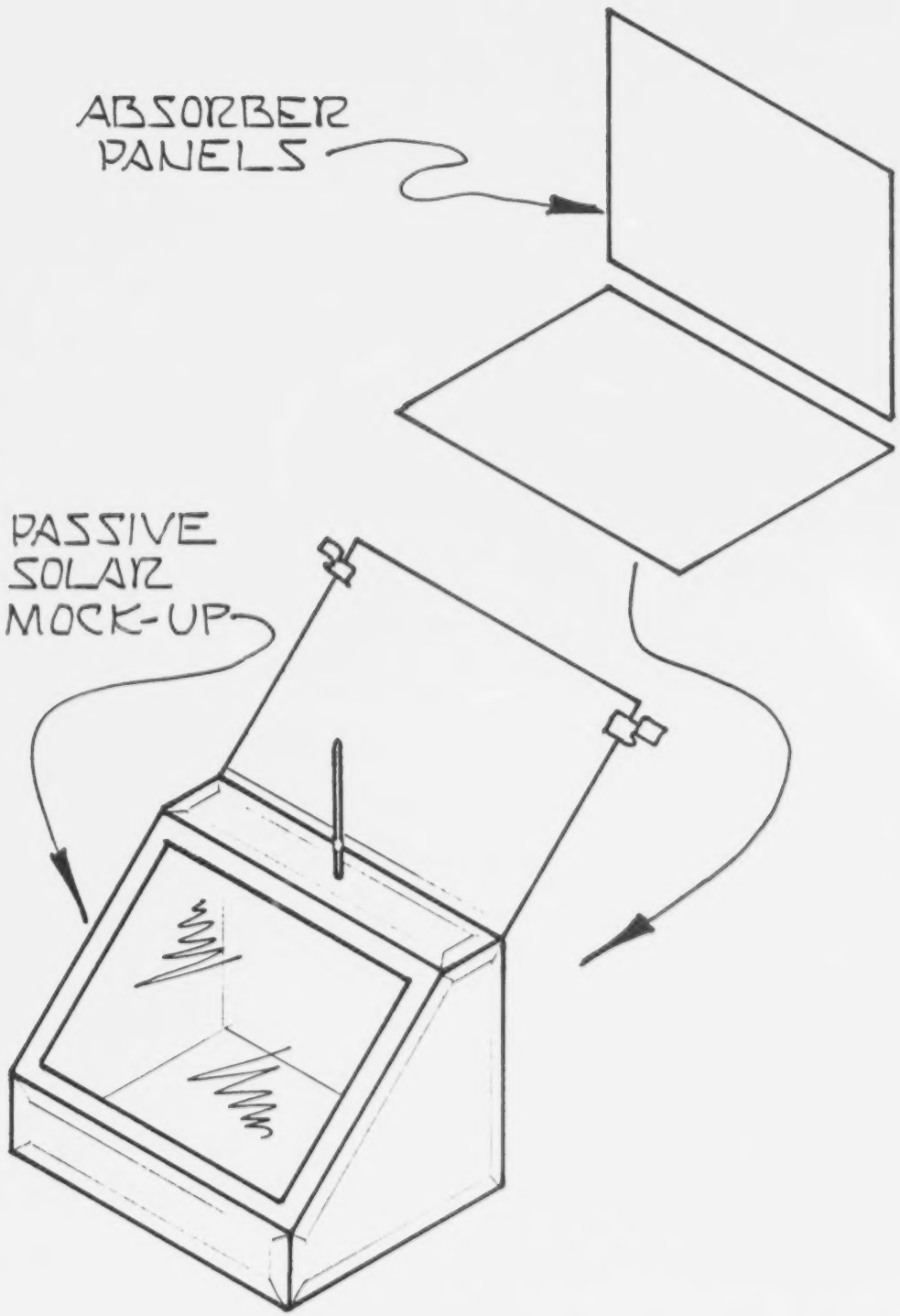


Figure 1-4 Installing an Absorber Panel

6. When your teacher tells you it is time, open the back of your passive solar mockup. Remove the two light colored absorber panels. Put one of the flat black panels across the bottom of your passive solar mockup. Put the other flat black panel across the back of your passive solar mockup. Close the back panel of your mockup and tape the two corners. Make sure your passive solar mockup is still oriented toward the sun for maximum solar gain.

7. When your teacher tells you it is time to start, read the thermometer and record the temperatures on the chart provided. Continue reading and recording your mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: FLAT BLACK ABSORBER PANEL

1. _____ 6. _____

2. _____ 7. _____

3. _____ 8. _____

4. _____ 9. _____

5. _____ 10. _____

8. When your teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to your classroom.

9. Using your data (temperatures), draw a line graph illustrating the affect of absorber surface colors on heat gain.

10. Heat gain with flat black absorber panels was _____ the heat gain with light colored absorber panels.

A. less than
B. greater than
C. equal to

TESTING THE EFFECT OF INSULATION

1. To test the effects of insulation on heat gain, you will need the following materials:

    * one set of insulation panels for your passive solar mockup
    * one passive solar mockup
    * one thermometer
    * one roll of duct tape

2. Using the templates provided by your teacher, lay out the parts of your passive solar mockup on rigid insulation. Using a utility knife, cut out each insulation panel for your passive solar mockup. Be very careful when using the utility knife. Make sure you protect the working surface underneath the insulation with a piece of hardboard.

3. Take your passive solar mockup to an outdoor site with an unobstructed orientation to the sun. Orient your passive solar mockup toward the sun for maximum solar gain. Make sure your mockup contains two flat black absorber panels.

4. Install a thermometer through the top of your mockup. Make sure you can still read it easily. Be careful, thermometers break easily.

5. When your teacher tells you it is time to start, read the thermometer and record the temperature on the chart provided. Continue reading and recording your mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: WITHOUT INSULATION

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

6. When your teacher tells you it is time, turn your passive solar mockup away from the sun and remove the thermometer. Using duct tape, fasten the insulation panels to your passive solar mockup (see Figure 1-5). Insulate the front, top, back, bottom, and sides of your mockup. Do not block the window on your passive solar mockup with insulation. When you have finished, make sure your mockup's back panel will still open and close.

7. Reinstall the thermometer through the top of your mockup. Do not use the thermometer itself to punch a hole through the insulation. Make sure you can still read the thermometer easily.

8. When your teacher tells you it is time to start, read the thermometer and record the temperature on the chart provided. Continue reading and recording your mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: WITH INSULATION

1. _____ 6. _____

2. _____ 7. _____

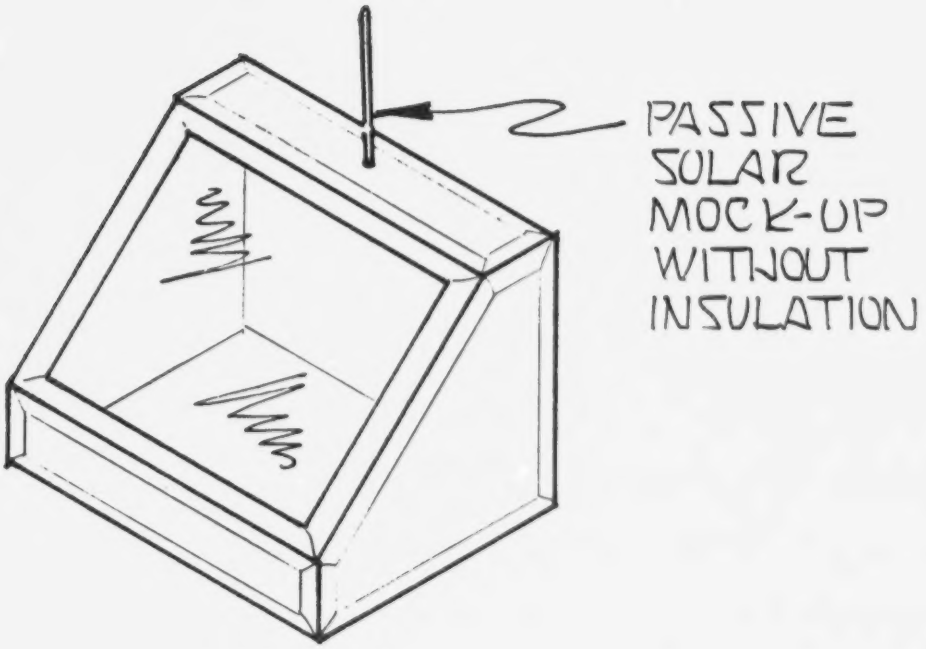
3. _____ 8. _____

4. _____ 9. _____

5. _____ 10. _____

9. When your teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to your classroom.

10. Using your data (temperatures), draw a line graph illustrating the effect of insulation on heat gain.



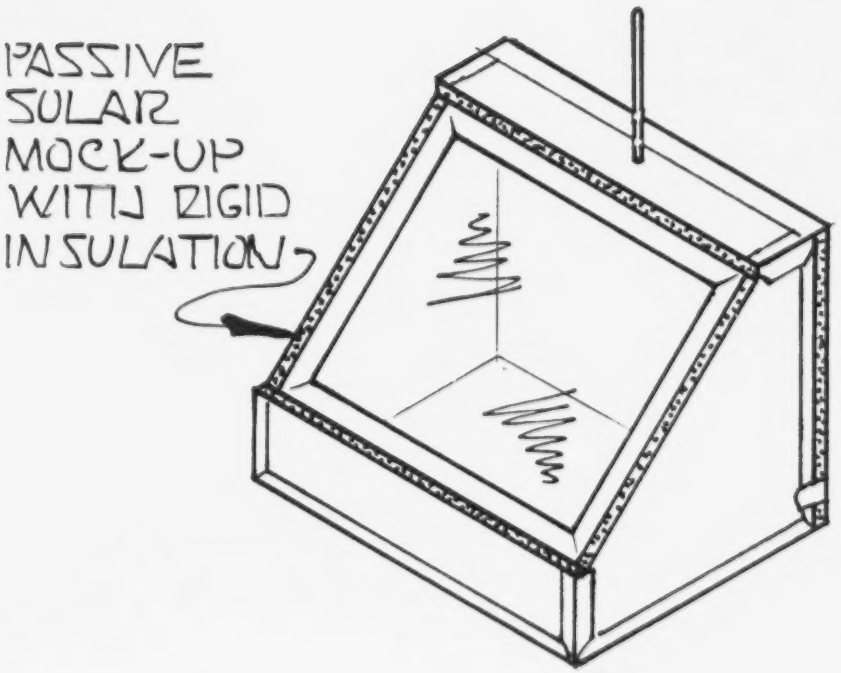


Figure 1-5 Installing insulation

11. Heat gain with insulation was _____ the heat gain without insulation.

A. less than
B. greater than
C. equal to

TESTING THERMAL MASS

1. To test the role of thermal mass in a passive solar system, you will need the following materials:

   * one passive solar mockup
   * two aluminum pop cans painted flat black
   * a thermal mass material (i.e., water, sand, pebbles, metal fasteners)
   * one thermometer
   * several pieces of duct tape

2. Prepare two containers of thermal mass for your passive solar mockup. Fill two pop cans painted flat black with a thermal mass material (see Figure 1-6).

3. Open the back of your passive solar mockup. Remove the absorber panel located across the back of your mockup. Place the two containers of thermal mass inside your mockup, reinstall the absorber panel across the back of your mockup. Close the back panel of your mockup and tape the two bottom corners.

4. Carefully take your passive solar mockup to an outdoor site with an unobstructed orientation to the sun. Orient your passive solar mockup toward the sun for maximum solar gain.

5. Install a thermometer through the top of your mockup. Make sure you can still read it easily. Be careful, thermometers break easily.

6. When your teacher tells you it is time to start, read the thermometer and record the temperature on the chart provided. Continue reading and recording your mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: IN THE SUN

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

7. When your teacher tells you it is time, move your mockup out of the sun. Continue to read and record your mockup's interior temperature every 60 seconds for 10 minutes.

TEMPERATURE READINGS: OUT OF THE SUN

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

8. When your teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to your classroom.

9. Using your data (temperatures), draw a line graph illustrating the effects of thermal mass in a passive solar energy system.

10. When the passive solar mockup containing thermal mass was moved out of the sun, its interior temperature _____

A. increased rapidly
B. increased slowly
C. stayed the same
D. decreased slowly
E. decreased rapidly

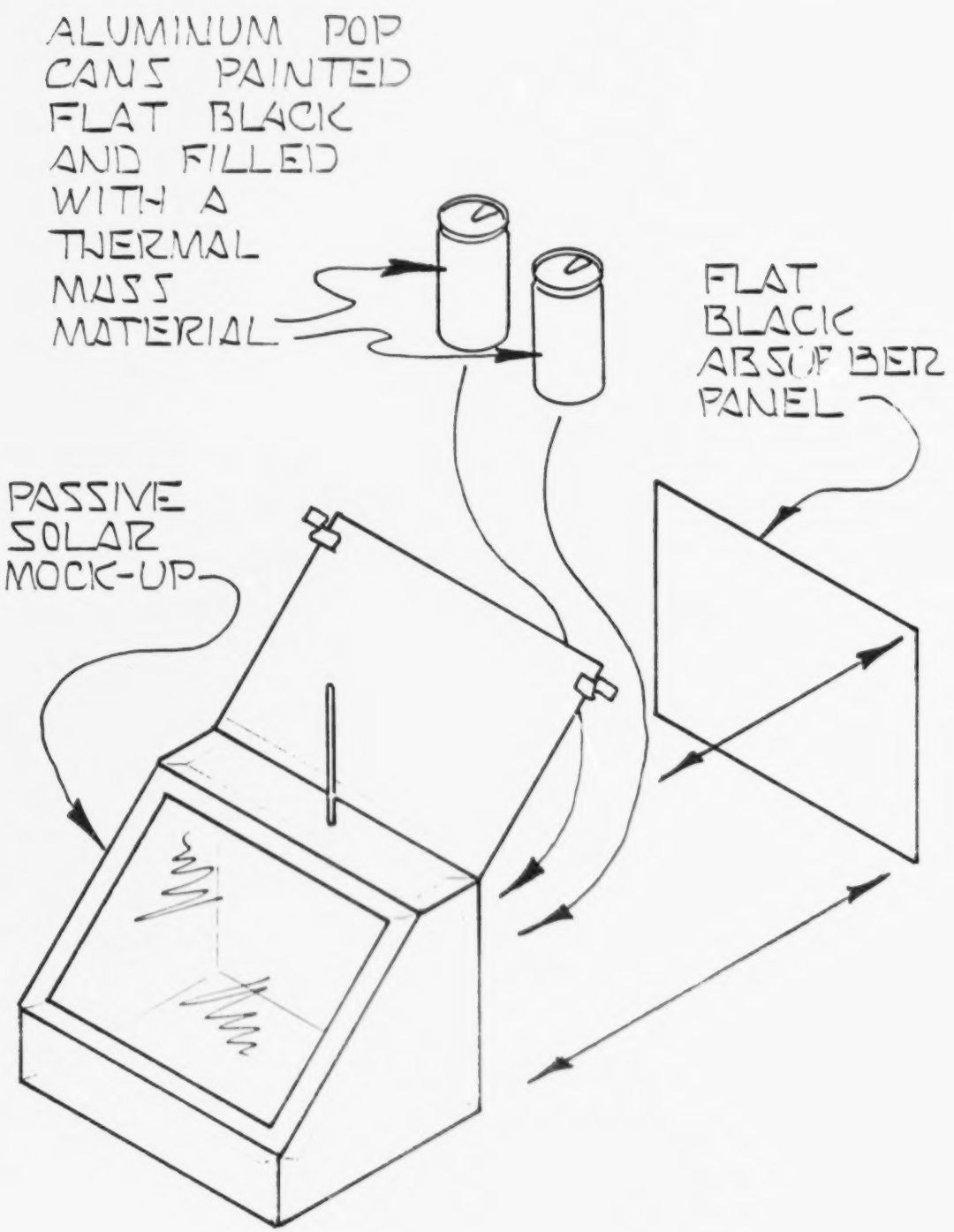

ALUMINUM POP CANS PAINTED FLAT BLACK AND FILLED WITH A THERMAL MASS MATERIAL
FLAT BLACK ABSORBER PANEL
PASSIVE SOLAR MOCK-UP

Figure 1-6 Installing a Thermal Mass

TESTING A CONVECTION DISTRIBUTION SYSTEM

1. To test a convection distribution system, you will need the following materials:

    * one passive solar mockup
    * two thermometers

2. Most passive solar energy systems rely heavily on convection to distribute heat throughout a building. Convection is the transfer of heat by means of the physical movement of a gas or liquid. Since heat rises, many passive solar energy systems use vents to move heat from a collection area to a living space. These vents are typically located at the bottom and top of the collection area. Cool air enters the bottom vent, is heated, rises, and leaves through the top vent. To distribute heat through your passive solar mockup, you need to create a cool air inlet and a hot air outlet. To create the cool air inlet, cut a 2" hole in the front of your passive solar mockup (see Figure 1-7). To create a hot air outlet, cut a 2" hole in the top of your passive solar mockup

3. Take your passive solar mockup to an outdoor site with an unobstructed orientation to the sun. Orient your passive solar mockup toward the sun for maximum solar gain.

4. Install one of the thermometers in front of the cool air inlet (see Figure 1-7). Install the other thermometer inside the hot air outlet. Make sure you can read both thermometers easily. Be careful when installing the thermometers as they break easily.

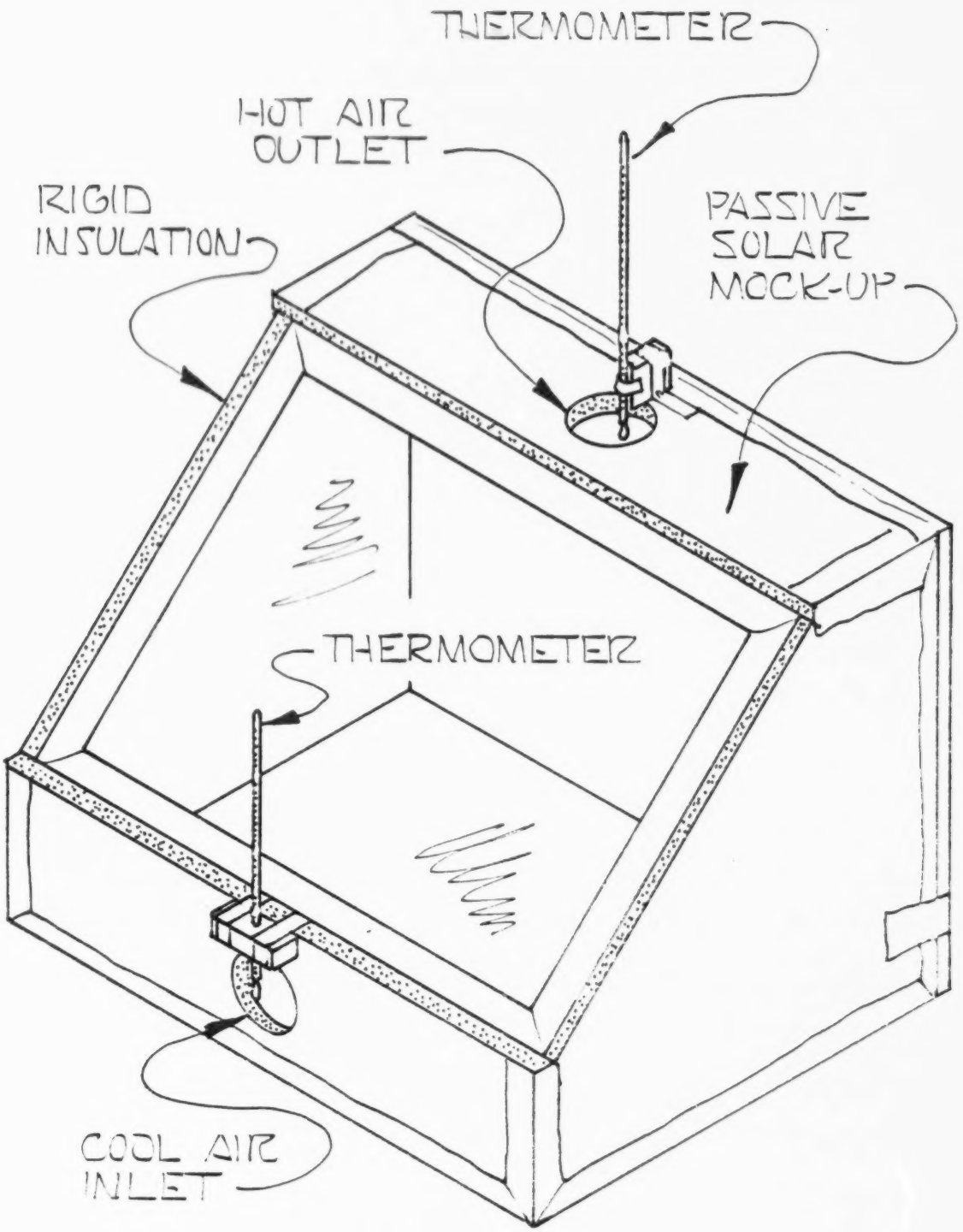


Figure 1-7 Creating a Convection Distribution System

5. When your teacher tells you it is time to start, read both thermometers and record the temperatures on the chart provided. Continue reading and recording your mockup's input and output temperatures every 60 seconds for 15 minutes.

TEMPERATURE READINGS: CONVECTION DISTRIBUTION

	Inlet Temperatures		Outlet Temperatures
1	_____	1	_____
2	_____	2	_____
3	_____	3	_____
4	_____	4	_____
5	_____	5	_____
6	_____	6	_____
7	_____	7	_____
8	_____	8	_____
9	_____	9	_____
10	_____	10	_____
11	_____	11	_____
12	_____	12	_____
13	_____	13	_____
14	_____	14	_____
15	_____	15	_____

6. When your teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to your classroom.

7. Using your data (temperatures), draw a line graph illustrating the input and output temperatures of your passive solar mockup.

8. Passive solar mockup output temperatures were _____ the inlet temperatures.

A. greater than
B. equal to
C. less than

UNIT: Exploring Solar Energy

LESSON 2: Active Solar Energy

Objectives	Lesson Content	Learning Activities	Ref.
A. Following a discussion, students will be able to: -identify a definition for active solar energy. -identify the two basic types of active solar energy systems. -identify the two basic types of active solar collectors. -identify the four basic solar energy conversion processes. -identify four applications for active solar energy systems. -identify the storage mediums used in the two basic types of active solar systems.	A. Active solar energy 1. Active solar energy systems: a. use collectors to collect and convert the sun's radiant energy to thermal energy. b. utilize energy consuming mechanical and electrical devices to operate and control the system. 2. Types of active solar systems a. air systems b. liquid systems 3. Types of active solar collectors a. flat plate b. concentrating 4. Types of storage mediums a. rock (air sys.) b. water (liquid sys.) 5. Energy conversion processes a. collection b. conversion c. storage d. distribution	A. Teacher Guided Discussion 1. Ask students if they have seen a home or building that had solar collectors on its roof. Introduce students to the concept of active solar energy. 2. Using OT #2-1, discuss the two basic characteristics of an active solar energy system. 3. Using OT #2-2, discuss the two basic types of active solar systems. 4. Using OT #2-3, discuss the two basic types of active solar collectors. 5. Using OT #2-4, discuss the two types of storage mediums used in active solar systems. 6. Using OT #2-5, discuss the active solar energy conversion processes. 7. Using OT #2-6, discuss applications for active solar technology.	

6. Active solar applications
   a. producing industrial steam
   b. heating living space
   c. heating domestic hot water
   d. air conditioning

B. Following a demonstration, in a lab activity, students will be able to:
- -build a simple active solar collector according to written and verbal instructions.
- -set up and test and active solar farm using their collectors.
- -collect and interpret input versus output temperature readings.

B. Building and testing active solar collectors.

1. Building a parabolic collector
   a. making parabolic ribs
   b. making the reflective trough
   c. making collector stakes
   d. preparing the absorber pipe
   e. assembling the parabolic trough collector
2. Setting up a solar farm
   a. staking parabolic collectors into the ground
   b. linking solar collectors together
   c. installing and priming the pump system
   d. establishing input and output recepticles
   e. orienting solar collectors for maximum solar gain
3. Testing the solar farm
   a. circulating water through the system rapidly while collecting input and output temperatures

B. Learning Activities

1. Demonstrate how to use the tools and materials needed to make a parabolic collector
2. Demonstrate how to make a parabolic collector.
3. Provide students with HO #2-1.
4. Divide your class into groups of three students and assign each group a work station.
5. Have students begin making their parabolic collector.
6. Circulate around the room and provide individual instruction as needed.
7. When students have completed their collectors, explain how to set up and test a solar farm.
8. Have students set up and conduct the experiment on the lab sheet.
9. After students have completed the lab activity, have each team graph and interpret their data and answer the questions provided on the lab sheet.
10. Collect and evaluate your students collectors and lab sheets.

b. circulating water through the system slowly while collecting input and output temperatures
c. graphing and interpreting input and output data
d. answering conclusion questions

OH #2-1

ACTIVE SOLAR ENERGY SYSTEMS:

- use collectors to collect and convert the sun's radiant energy to thermal energy.
- utilize energy consuming mechanical and electrical devices to operate and control the system.

OH #2-4

TYPES OF STORAGE MEDIUMS:

- rock (air system)
- water (liquid system)

OH #2-5

ENERGY CONVERSION PROCESSES:

- collection
- conversion
- storage
- distribution

OH #2-6

ACTIVE SOLAR APPLICATIONS:

- producing industrial steam
- heating living space
- heating domestic hot water
- air conditioning

ACTIVE SOLAR ENERGY

Preparation Hints:

1. Review the materials provided, duplicate HO #2-1, and prepare the transparencies needed to prepare this lesson.

2. During the lab activity, your students will be building parabolic collectors. Prior to implementing this lesson, you will need to set up one work station for every three students in your class. Each work station will need the materials described in the lab sheet. In addition, students will need access to spray adhesive, a band saw, a drill press equipped with an appropriate drill bit, and an electric drill equipped with a 1/8" drill bit.

3. To help students lay out an accurate parabolic curve, use the procedure described in Figure 2-1 to make hardboard templates. Students can use the templates to trace a parabolic curve onto their material. Have students use a band saw to cut along the outside of the parabolic curve when making a parabolic rib.

4. During the lab activity, students will be setting up and testing an active solar collector farm. Prior to implementing this lesson, you will need to collect the materials listed on the lab sheet. You can purchase a garden hose pump that attaches to an electric drill from most hardware stores.

5. On a sunny day, you should be able to heat water over 120 degrees Fahrenheit. You need to use thermometers with a range beyond 120 degrees Fahrenheit. Consider borrowing thermometers from your school's science department. It is very easy to damage cheap thermometers during this lab activity.

Content Presentation Hints:

1. Consider showing your students a film or videotape on active solar energy.

2. Consider conducting a field trip to a home or building equipped with an active solar system. Another option is to visit an active solar system dealership.

3. Consider inviting an architect or representative from a solar energy firm to talk to your class about solar energy systems.

4. Consider taking your class to the library for one class period. While there, your students could gather information about various active solar systems. The different systems researched could include air systems, liquid systems, closed loop systems, open loop systems, retrofit systems, solar farms, and collector designs.

4. When discussing applications for solar energy, ask students to cite examples of active solar energy at work in your community. Their examples might include items such as swimming pool heating systems, window collectors, hot water systems, solar grain dryers and space heating systems.

Learning Activity Hints:

1. To save time, consider precutting as many of the collector components as possible.

2. When demonstrating how to make a parabolic collector, explain how to use spray adhesive (contact cement). Emphasize the importance of applying adhesive to both surfaces, allowing the adhesive to dry, aligning both surfaces before they make contact, and how to press the two surfaces together. Demonstrate how to use a pin to remove air bubbles between the reflective material and the hardboard.

3. To make the hardboard more pliable, use a table saw to cut kerfs across the back of the hardboard. The kerfs should be about 1 inch apart, and running the length of the hardboard. When forming the hardboard around the parabolic ribs, start the fastening process in the center of the parabolic curve. Using a sponge, apply generous amounts of water to the back side of the kerfed hardboard. Gently push the edges of the parabolic trough around the parabolic ribs. Working from the center of the parabolic curve, install a screw every four inches along the parabolic curve. When the parabolic trough is complete, install a flat black copper pipe through the focal points. Slip a stake over each end of the absorber pipe. Your parabolic collector is now ready to be tested.

4. For the best collector performance, select a site with an unobstructed orientation to the sun. Ask each team to set up their collector testing station as illustrated in Figure 2-2. Have students orient their collectors toward the sun for maximum solar gain. For

best solar collector performance, adjust the parabolic trough until the reflected light rays on each parabolic rib are focused onto the absorber pipe. When the solar collector is properly adjusted, the back side of the absorber pipe should appear gray, while the front half remains flat black. Tell your students not to touch the absorber pipe because it will become very hot. Use short lengths of garden hose about 12" long to connect the parabolic collectors. When all the collectors have been linked, connect the electric drill pump, locate a bucket at each end of the array, and fill the first bucket with water.

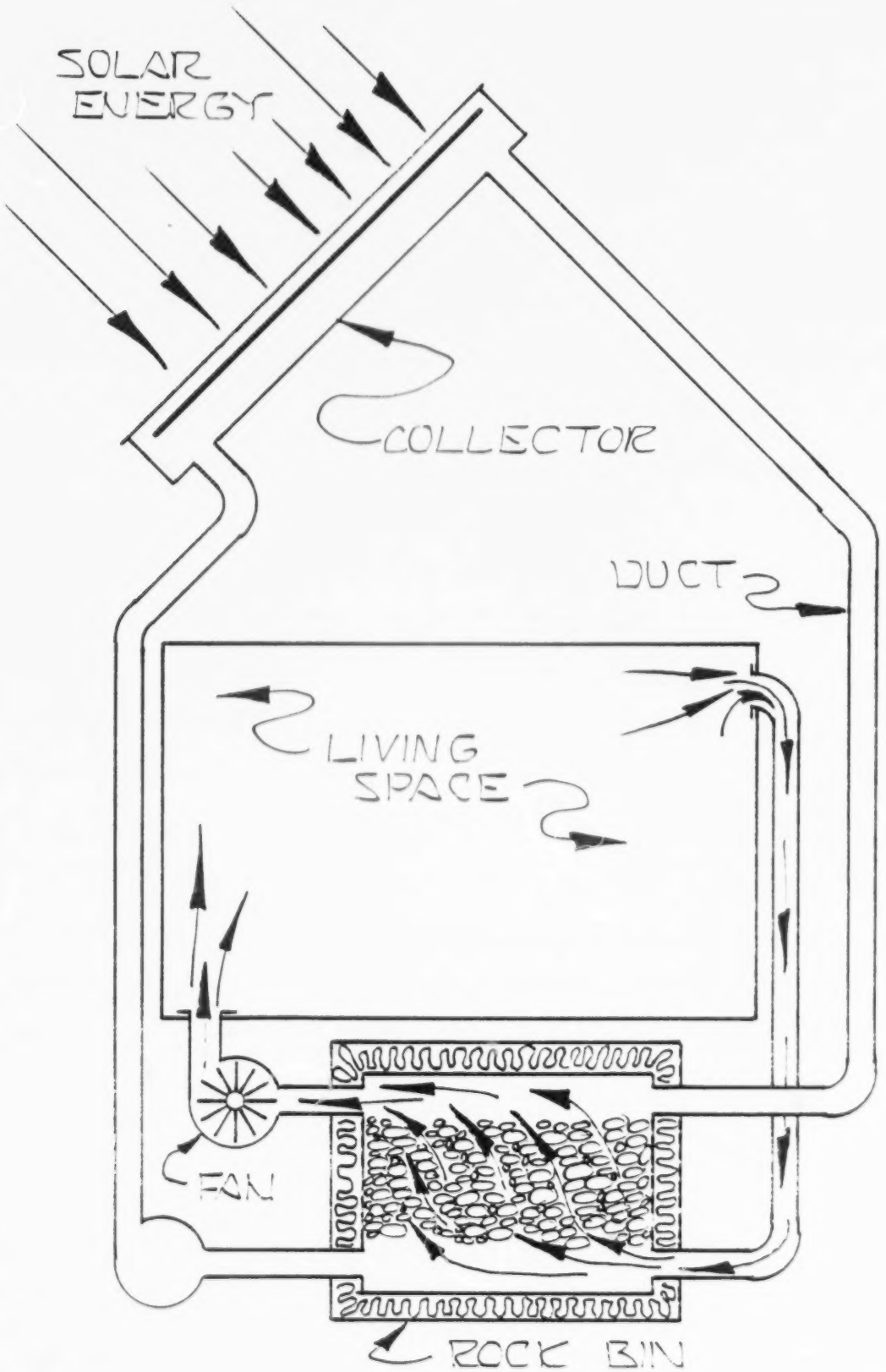
5. Inspect the solar collector array before allowing students to start their testing activities. Make sure there is a safe distance between water and electrical devices. Once their set-up passes inspection, provide two thermometers. Instruct students to install the thermometers in their defined locations, and to begin collecting data according to the instructions provided on the lab sheet.

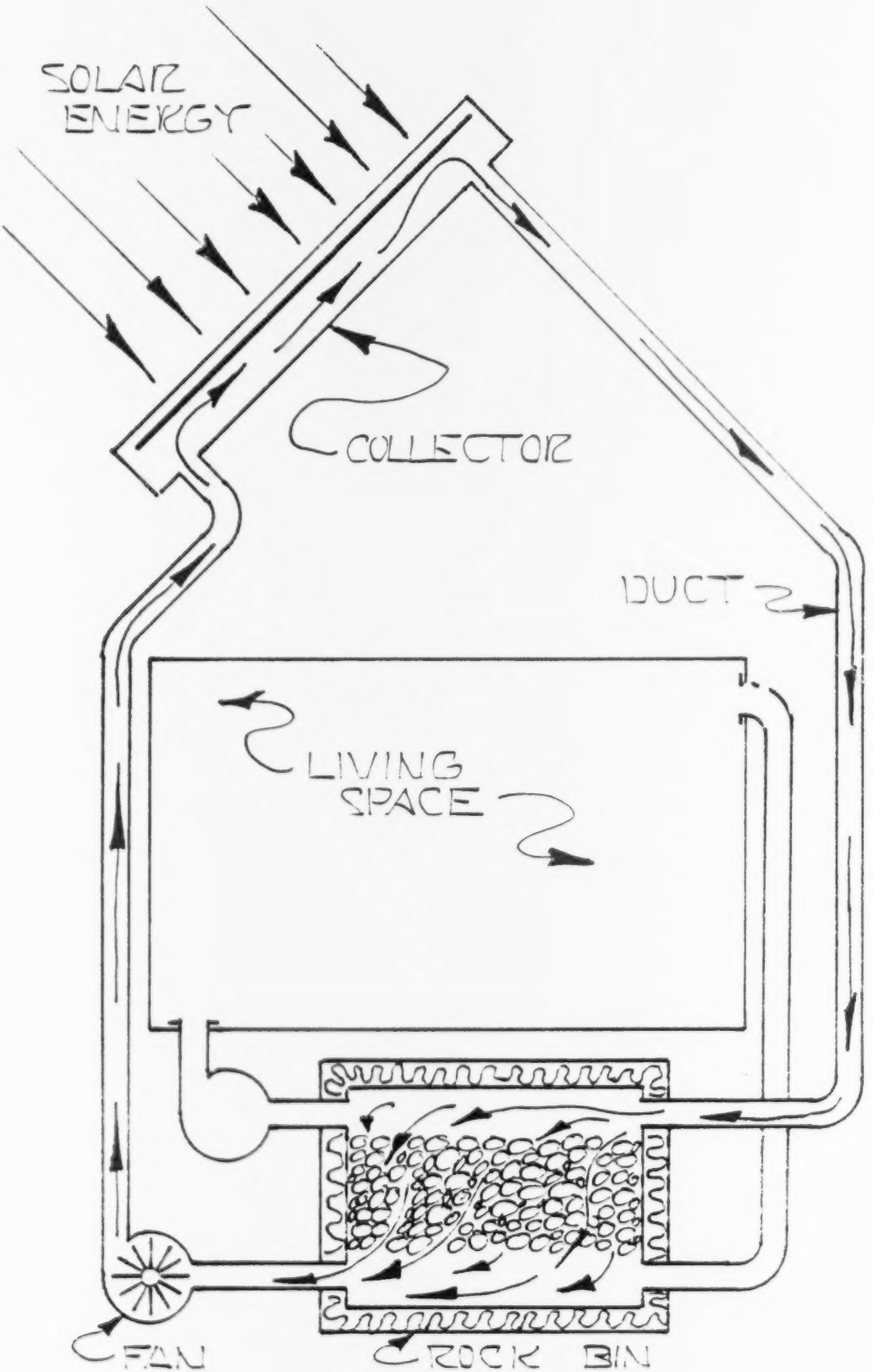
6. This learning activity provides an excellent opportunity to promote technology education in your school community. Consider taking pictures of your students and their collector array for future displays, newspaper articles, presentations, and other public relations activities.

7. Your students will probably want to play with the pump once they learn the effect it has on output temperatures. Do not be surprised if students try to superheat the water by stopping the pump and allowing the water to set in the collector system for several minutes. If the students monitoring the output temperature is not aware of this activity, he or she could be seriously burned. To prevent accidents, consider integrating this experiment into the lab activity. While conducting this experiment, make sure students keep hands and fingers away from the output hose.

8. If you have access to a computer, consider using a data acquisition software package to collect temperature data electronically.

9. Consider displaying your solar collectors and lab sheets in a location where other members of the school community can see the results of your students' active solar activities.


SOLAR
ENERGY
COLLECTOR
DUCT
LIVING
SPACE
FAN
ROCK BIN


SOLAR
ENERGY
COLLECTOR
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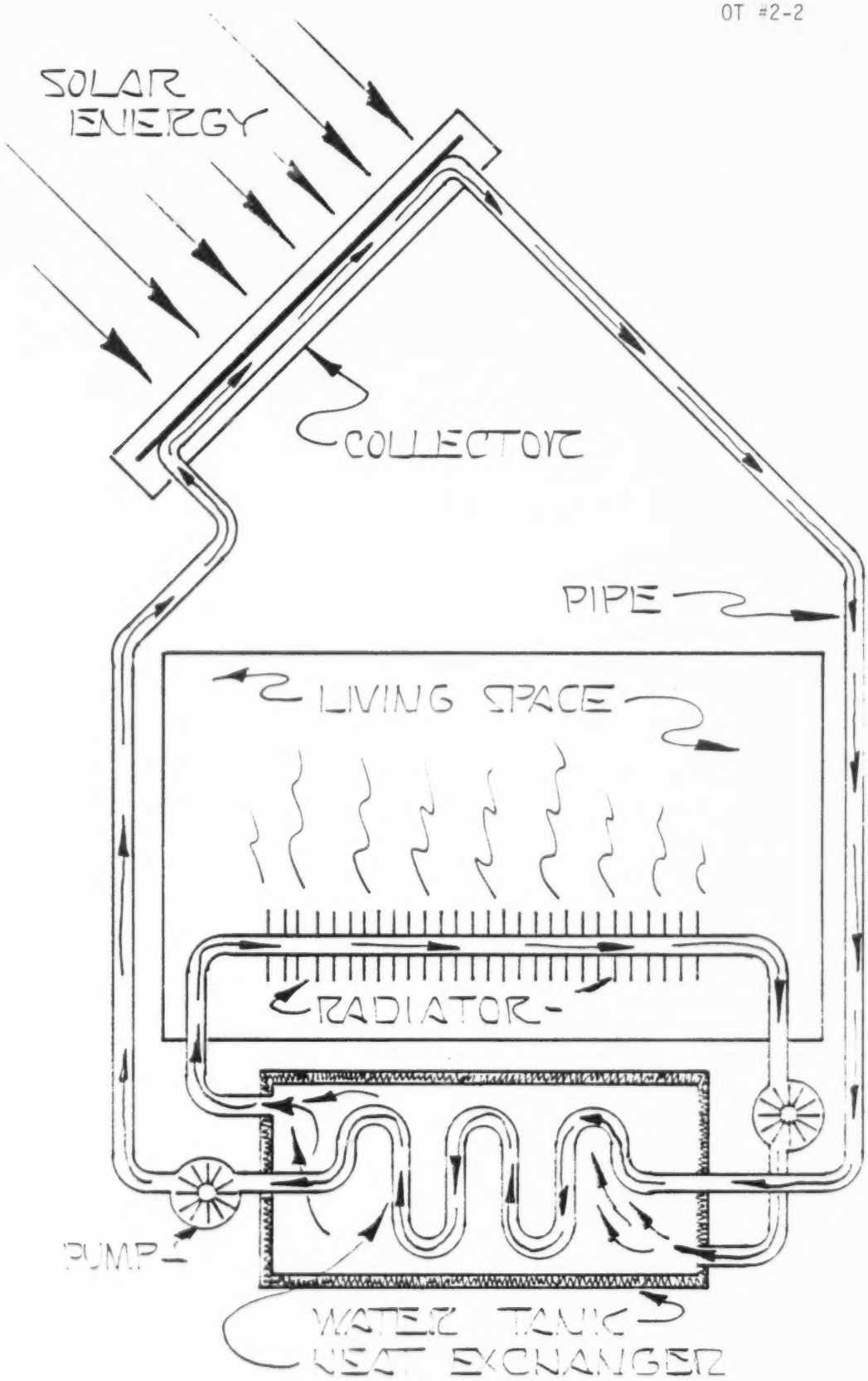
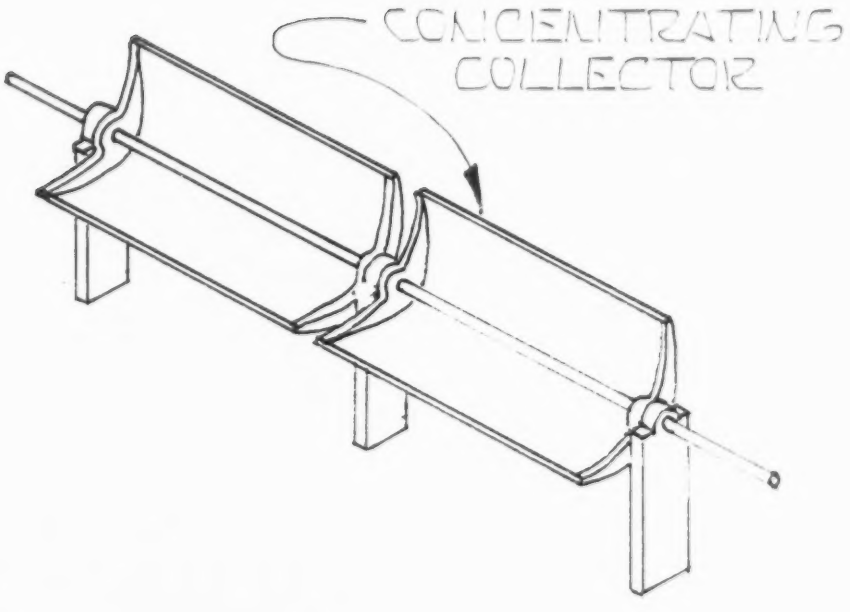
LIVING
SPACE
FAN
ROCK BIN


SOLAR ENERGY
COLLECTOR
PIPE
LIVING SPACE
RADIATOR
PUMP
WATER TANK
HEAT EXCHANGER

FLAT-PLATE
COLLECTOR


CONCENTRATING
COLLECTOR

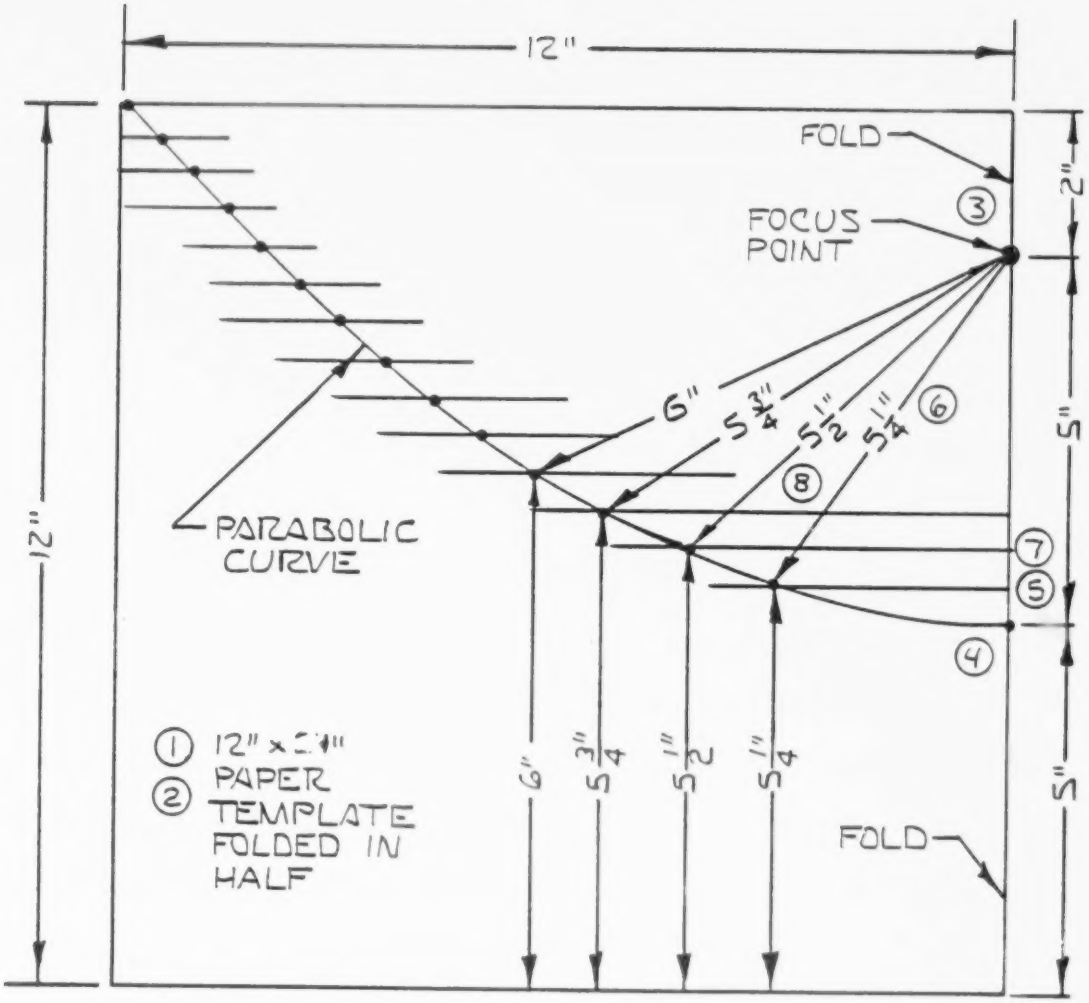


FIGURE 2.-1

MAKING A PARABOLIC TEMPLATE

PROCEDURES FOR MAKING A PARABOLIC COLLECTOR

1. Cut out a sheet of paper 12" wide and 24" long.
2. Fold the sheet of paper in half so it is 12" by 12".
3. Locate the focus point 2" from the top of the paper along the fold.
4. Locate a second point 5" from the focus point along the fold.
5. Measure and locate a point 5 1/4" from the bottom of the paper along the fold. Draw a line at a right angle with the fold from the point.
6. Measure and locate a point 5 1/4" from the focus point on the line.
7. Measure and locate a point 5 1/2" from the bottom of the paper along the fold. Draw a line at a right angle with the fold from the point.
8. Measure and locate a point 5 1/2" from the focus point on the line.
9. Continue this process of laying out points in 1/4" increments until you have reached the top of the paper.
10. When all the points have been layed out, use an irregular curve and pencil to connect the points.
11. Using a pair of scissors, cut along the line.
12. Unfold the parabolic template and transfer the focus point and the parabolic curve to two pieces of plywood.
13. Drill a hole through the focus point on the plywood for the water pipe.
14. Using a band saw, cut along the parabolic curve to make the right and left sides of the parabolic collector.
15. Form and fasten the reflective material around the sides.

ACTIVE SOLAR ENERGY

During your passive solar learning activities, you discovered the potential of collecting the sun's radiant energy. Eventhough the technology you used was very simple, you were able to convert solar energy to a more useful form of energy, heat. Contrary to popular beliefs, solar energy systems do not have to be complicated to work effectively.

Passive solar homes and buildings use architectural features to collect, convert, store, and distribute solar energy. Active solar energy systems use collectors to collect and convert the sun's radiant energy. Unlike passive solar energy systems, active systems use mechanical and electrical devices. These devices often need electrical energy to work.

There are two basic types of active solar systems: air systems and liquid systems. Air systems use air for a heat transfer fluid. Using a fan, cold air is pumped to the solar collector. Once inside, it is circulated through the absorber system. When the absorber system is exposed to solar energy, it becomes very hot. As the air circulates through the absorber system, it too becomes hot. When the air leaves the collector, the heat it carries can be stored or used to heat living space. To store the heat, the air is typically circulated through a bin filled with rocks. As the air travels through the bin, the rocks absorb the heat. When solar energy is not available, room air is circulated through the bin, heated by the rocks and returned to the living space. Air systems use heating ducts and fans to distribute the heat.

Air systems are usually simpler, cheaper, and require less maintenance than liquid systems. One major disadvantage of air systems is they are not very effective for heating water.

Liquid systems use water or an antifreeze solution as a heat transfer fluid. Like air systems, the heat transfer fluid is pumped through an absorber system where it becomes hot. After it has been heated, the heat transfer fluid can be circulated through radiators. The radiators, in turn, heat the air in the living space. Excess heat is typically stored in a tank of water. The hot water can be used for domestic purposes. Pipes and pumps are used for heat distribution. Preventing the heat transfer fluid from freezing is a major consideration when designing and installing liquid systems.

There are two basic types of solar collectors used in active solar systems. The most commonly used is a flat plate collector. The collector is comprised of a thin rectangular box with its top face covered with a glazing material. The glazing material can be glass or clear plastic. The rectangular box houses and insulates the absorber system. If the collector is designed for a liquid system, the absorber system is a network of pipes connected to a large sheet of metal. If the absorber system is designed for an air system, it is usually a corrugated or thin sheet of metal. In both cases, the absorber system is treated with a special flat black paint.

The second basic type of solar collector is called a concentrating collector. These collectors use a reflective surface to concentrate solar radiant energy onto an absorber system. These collectors can only be used in liquid systems. Because the solar energy is concentrated, these collectors can produce temperatures up to 1,000 degrees Fahrenheit. When the sun's position changes, concentrating collectors must be adjusted. This adjustment process is called tracking. In order for concentrating collectors to be efficient, they must be tracked with the sun throughout the day.

Most active solar systems require more than one collector. The collector area for a typical house can range between 1/4 and 1/3 of the floor area being heated.

The most popular application for active solar technology is heating water for domestic, industrial, and commercial use. These hot water applications range from heating swimming pools to producing steam for industrial applications. Both air and liquid systems can be used to heat residential homes. However, many experts feel that active solar heating is best suited for commercial and industrial applications. Lastly, solar energy systems can be used to provide air conditioning. However, active solar air conditioning systems are very expensive.

Active solar energy systems use collectors to convert the sun's radiant energy to useful thermal energy. Active systems use mechanical and electrical devices that require electrical energy. The two basic types of active systems are air systems and liquid systems. Air systems use ducts and fans for heat distribution, and use rocks for heat storage. Liquid systems use pipes and pumps for heat distribution, and use water for heat storage. The two basic types of solar collectors are flat plate collectors and concentrating collectors. Flat plate collectors enclose the absorber system in a rectangular box with glass on one face.

Concentrating collectors use a reflective surface to concentrate solar energy onto an absorber system. Active solar systems can be used to heat water, heat living space, and air condition living space.

Learning Activities:

Solar collectors are the most important element in an active solar system. They collect the sun's radiant energy and convert it to useful thermal energy. To use the thermal energy, a heat transfer fluid must be circulated through the collector. During the following lab activity, you will be building a simple parabolic collector. When your collector is finished, you will test it by linking it with other collectors and circulating water through the system. In addition, you will be collecting and interpreting input versus output temperature readings.

Building a Parabolic Solar Collector:

1. To build a simple parabolic collector, you will need the following materials:

    * one length of 1/2" copper pipe, 30 inches long
    * two pieces of 1 x 4 lumber, 2 feet long
    * two sheets of plywood, 3/4" thick, 8" wide, and 24" long
    * one sheet of 1/8" hardboard, approximately 28" wide and 24" long
    * spray adhesive
    * flat black paint
    * enough commercial grade aluminum foil or reflective mylar (aluminized) to cover the hardboard
    * 14 1/2" long #6 pan head screws
    * one 10 foot long of duct tape

2. Using the template provided by your instructor, lay out a parabolic curve and its focal point on both sheets of plywood. Using the band saw, cut along the outside of the parabolic curve. Using a drill press equipped with the appropriate drill bit, drill a hole through the focal point on each sheet of plywood. Make sure you follow all the safety rules when using power machines.

3. The next step is to glue aluminum foil to your piece of hardboard. Before using any glue, cover your working surface with newspaper. Position your hardboard and several strips of aluminum foil on the newspaper. Apply a thin coat of adhesive to the top of the hardboard and to the back of the aluminum foil. Allow the glue to dry. When the glue is dry, position one

strip of aluminum foil over the top of the hardboard so the glued surfaces are facing each other. Allow one corner of the aluminum foil to touch the hardboard. Press the two materials together. Gradually allow more aluminum foil to come in contact with the hardboard. Continue pressing the two materials together until one complete sheet of aluminum foil has been laminated to the hardboard. Repeat this process with additional sheets of aluminum foil until the hardboard is completely covered with the reflective material. Trim the excess aluminum foil around the hardboard. Tape the edges of the hardboard with duct tape.

4. It is now time to assemble your collector (see Figure 2-2). Position the edges of your hardboard on top of the two parabolic ribs. Starting in the center, drive a screw through the center of the hardboard edge to the center of the parabolic curve at each end of the collector. Once the center has been fastened, bend the hardboard around the parabolic ribs. Insert a screw every three to four inches along the parabolic curves until you have a parabolic trough.

5. Prepare the absorber system by painting your copper tubing flat black. After the paint dries, insert the flat black pipe through the holes in the parabolic ribs. Drill a hole near the end of each 1 X 4 stake. Slip a stake over each end of your parabolic collector. You are now ready to set up and test your parabolic collector.

Setting Up and Testing an Active Solar System:

Review the active solar energy lab sheet. Read the problem carefully, read the research questions, complete the hypothesis section, and set up the experiment as illustrated in Figure 2-3. Conduct the experiment according to the procedures provided and report your findings. When you have finished, clean up the test site according to your teacher's instructions.

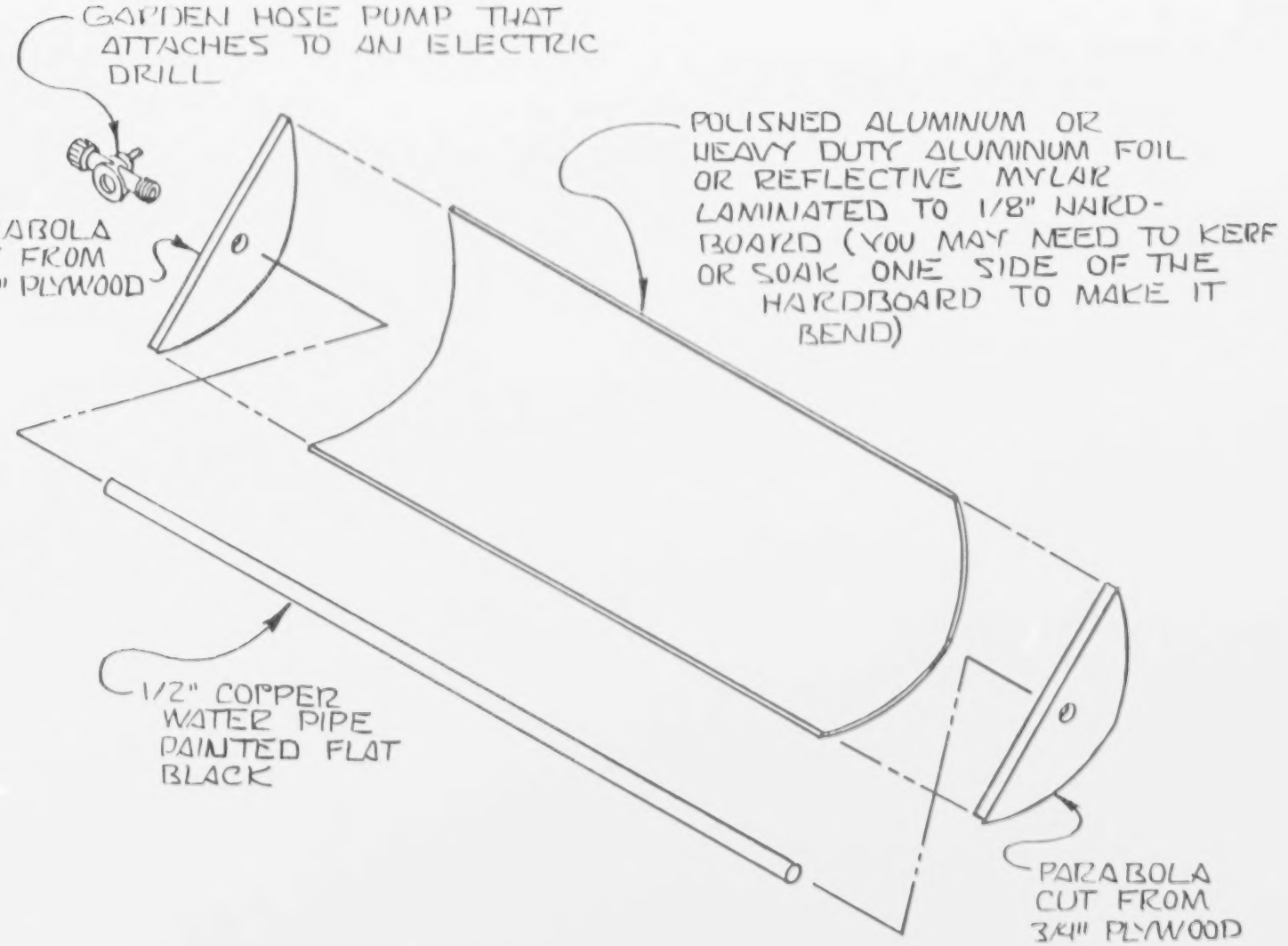

GARDEN HOSE PUMP THAT ATTACHES TO AN ELECTRIC DRILL
POLISHED ALUMINUM OR HEAVY DUTY ALUMINUM FOIL OR REFLECTIVE MYLAR LAMINIATED TO 1/8" HARD-BOARD (YOU MAY NEED TO KERF OR SOAK ONE SIDE OF THE HARDBOARD TO MAKE IT BEND)
PARABOLA CUT FROM 3/4" PLYWOOD
1/2" COPPER WATER PIPE PAINTED FLAT BLACK
PARABOLA CUT FROM 3/4" PLYWOOD

FIGURE 2-2
PARABOLIC COLLECTOR

62

ACTIVE SOLAR LAB SHEET

The Problem:

Given the questionable future of fossil fuel resources, solar energy has become a viable alternative energy source. Solar energy is free. However, the technology required to harness the sun's radiant energy is expensive. Only a small percentage of the population can afford the commercially available active solar systems. Even the most basic retrofit systems cost thousands more than conventional heating systems. There is a need to develop affordable and appropriate solar energy technology that the average homeowner can utilize. Therefore, your challenge is to develop and test an affordable solar collectors that the average do-it-yourselfer could build. Based on your experience, determine if the average handyperson could utilize this appropriate technology for heating living space and/or water.

Questions:

1. Do active solar systems have to be "high tech" to work effectively.

2. What effect does increasing or decreasing the speed of the fluid circulating through a collector have on its output temperature.

Hypothesis:

1. Which of the following do you believe will prove to be true?

   A. In order for a solar collector to be effective, it must be made out of special materials.

   B. Active solar collectors are too complicated for the average handyperson to build and use on their home.

   C. Solar collectors can be made out of common everyday materials and are easy to make.

2. If you increase the speed of a fluid (air or water) circulating through a solar collector, the fluid's output temperature will _____.

   A. decrease
   B. increase
   C. stay the same

Procedures:

1. Make sure your collector is made according to the plan and your teacher's instructions.

2. To test an active solar energy system, you will need the following materials:

   * all the parabolic collectors made by your class
   * one garden hose pump that attaches to an electric drill
   * two buckets
   * two thermometers
   * one C-clamp for every parabolic collector
   * one 12" section of garden hose for every parabolic collector
   * one portable electric drill
   * one extension cord
   * several gallons of water
   * access to an outdoor receptacle
   * an outdoor site with an unobstructed orientation to the sun

3. Once outdoors, set up and orient your solar collector as illustrated in Figure 2-3. Orient your collector for maximum solar gain.

4. When you have finished setting up your collector, ask your teacher to inspect the system and give you the okay to test.

5. After your teacher gives your team the okay to start, read and record the temperature of input fluid. Start pumping the fluid through the collector at a rapid and even rate. Read and record the fluid's output temperature. Read and record the fluid's input and output temperatures every 60 seconds for five minutes.

TEMPERATURE READINGS (FAST)

Input Temperature	Output Temperature
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____

6. Refill your input bucket if needed. Read and record the temperature of your input fluid. This time, pump the fluid through the collector at a slow and even rate. Read and record the fluid's output temperature. Continue reading and recording the fluid's input and output temperatures every 60 seconds until your teacher tells you it is time to stop.

TEMPERATURE READINGS (SLOW)

Input Temperature	Output Temperature
1. _____	1. _____
2. _____	2. _____
3. _____	3. _____
4. _____	4. _____
5. _____	5. _____
6. _____	6. _____
7. _____	7. _____
8. _____	8. _____
9. _____	9. _____
10. _____	10. _____
11. _____	11. _____
12. _____	12. _____
13. _____	13. _____
14. _____	14. _____
15. _____	15. _____

6. When your teacher tells you it is time, stop collecting data (temperatures), clean up the site, and return to your classroom.

Conclusions:

In teams, discuss how your collector performed and answer the following questions.

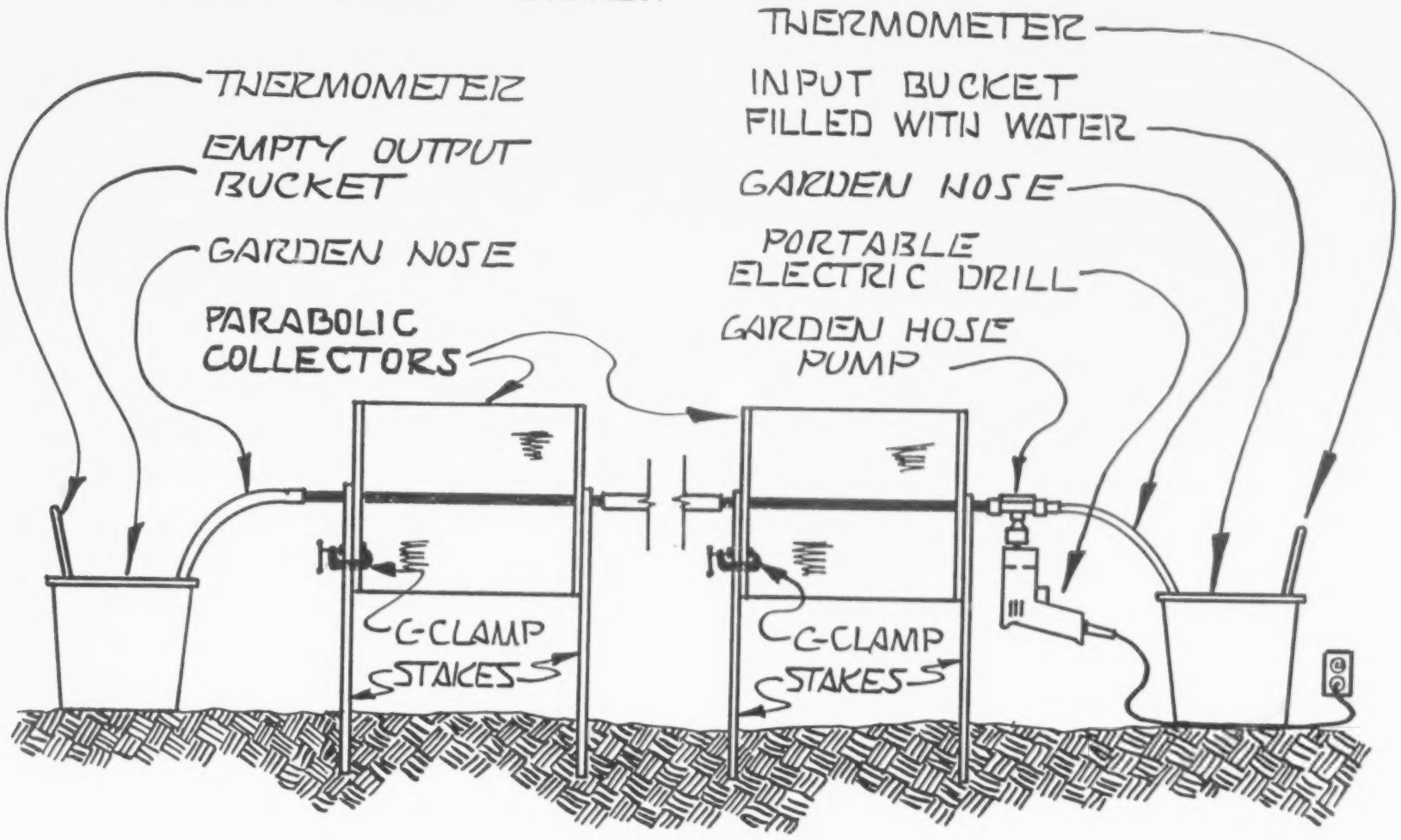
1. Do solar collectors have to be high tech to convert radiant energy into useful thermal (heat energy? Support your answer with evidence from your research and development activities.

2. What effect does increasing or decreasing the speed the fluid is circulating through the collector have on its output temperature? Explain your conclusion.

3. What are some of the advantages of your collector design?

4. What are some of the disadvantages of your collector design?

FIGURE 2-3, TESTING AN ACTIVE SOLAR ENERGY SYSTEM



UNIT: Exploring Solar Energy

LESSON 3: Evaluation

Objectives	Lesson Content	Learning Activities	Ref.
A. Following a discussion, students will be able to answer given concept questions regarding solar energy with a minimum of 70% accuracy.	A. Review 1. Passive solar energy a. characteristics b. techniques c. conversion process d. thermal mass e. applications 2. Active solar energy a. characteristics b. types of systems c. types of collectors d. conversion process e. applications	A. Teacher guided review 1. Review the major concepts explored in this unit. 2. Provide students with an opportunity to ask questions before taking the test. 3. Provide students with HO #3-1. Make sure each student has a pen or pencil. 4. Explain the directions for the test. 5. Have students read the test and answer the questions provided. 6. Collect the test and grade your students' performance. 7. Provide the students with feedback regarding their test performance as soon as possible.	

-61-

EXPLORING SOLAR ENERGY

Unit Test

Directions: Read each statement carefully. circle the letter of the answer you think best answers the question.

1. Solar energy is transmitted to the earth in the form of _____.

   A. chemical energy
   B. radiant energy
   C. mechanical energy
   D. thermal energy

2. The windows on a passive solar home are placed on the _____ side of the house.

   A. north
   B. west
   C. east
   D. south

3. Solar energy is _____.

   A. inexhaustible
   B. nonpolluting
   C. free
   D. all the above

4. The absorber system in an active solar collector is painted _____.

   A. glossy silver
   B. flat black
   C. white
   D. dark blue

5. When solar energy collection, conversion, storage, and distribution occur within the living space, it is referred to as a _____ system.

   A. indirect gain
   B. isolated gain
   C. direct gain
   D. active

6. When a thermal mass stands between the sun and the living space, it is referred to as a _____ system.

A. indirect gain
B. direct gain
C. isolated gain
D. active

7. Which of the following materials is not a good thermal mass?

A. brick
B. wood
C. ceramic tile
D. stone

8. Solar energy systems that use mechanical and electrical devices are called _____ systems.

A. direct gain
B. active
C. passive
D. indirect gain

9. Which of the following solar technologies utilizes architectural features to collect, convert, store, control, and distribute energy?

A. active systems
B. passive systems
C. liquid systems
D. air systems

10. Which of the following solar energy systems utilizes collectors, heating ducts, and fans?

A. indirect gain systems
B. direct gain systems
C. active air systems
D. active liquid systems

11. Which of the following solar energy systems utilizes collectors, pipes, and pumps?

A. direct gain systems
B. indirect gain systems
C. active air systems
D. active liquid systems

12. Which of the following types of solar collectors needs to be tracked with the sun?

A. concentrating collectors
B. flat plate collectors (air)
C. flat plate collectors (liquid)
D. all of the above

13. In a solar energy system, insulation is used to _____.

A. store thermal energy
B. collect solar energy
C. keep thermal energy from escaping
D. convert solar energy to thermal energy

14. In an active solar energy system, rock bins and tanks of water are used to _____.

A. collect solar energy
B. convert solar energy to thermal energy
C. distribute heat energy throughout the living space
D. store thermal energy

15. When a fluid is circulated through a solar collector on a sunny day, its temperature will _____

A. increase
B. decrease
C. stay the same
D. be unpredictable

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